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P01/7700 0.00-0223686.7

Request for grant of a patent

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Cardiff Road
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1.	Your reference	03 41456
2.	Patent application number	0223686.7 10 OCT 2002
3.	Full name, address and post code of the or each applicant	Nokia Corporation Keilalahdentie 4 02150 Espoo Finland
	Patents ADP number	76522170003
	If the applicant is a corporate body, give the country/state of its incorporation	FI
4.	Title of the invention	DEVICE OPERABLE AS A HOST
5.	Name of your agent	VENNER, SHIPLEY & CO
	"Address for service" in the United Kingdom to which all correspondence should be sent	20 LITTLE BRITAIN LONDON EC1A 7DH
	Patents ADP	1669004 ✓

6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or each of these earlier applications and the or each application number	Country	Priority application number	Date of filing
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and filing date of the earlier application		Number of earlier application	Date of Filing
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'YES' if:* *a) any applicant in 3. above is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body)*	YES		

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	5
Abstract	1 DML
Drawing(s)	3+3

10. If you are also filing any of the following state how many against each item.

Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1
Request for preliminary examination and search *(Patents Form 9/77)*	2
Request for substantive examination *(Patents Form 10/77)*	
Any other documents	

11. I/We request the grant of a patent on the basis of this application.

Signature: Venner, Shipley & Co.

Date: 10 October 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

PAUL DERRY
020 7600 4212

Device operable as a host

This invention relates to a device operable as a USB host, and to a system including such a device. The invention relates also to a device operable as a host, to a system including such, and to a device operable as a USB host.

The USB (universal serial bus) standard is in wide use today, and is commonly used to connect, for example, PCs (personal computers) or laptop computers to peripheral devices such as printers, scanners and the like. The USB 1.1 and 2.0 specifications require that a host device provides a voltage supply on a V_{BUS} line, for use by a non-host device connected thereto. In USB, only one host and one non-host can ever be present on a USB bus, with the non-host being termed a 'device'. However, in the following such devices are termed non-host devices.

A supplement called USB on-the-go (OTG) is proposed, and is discussed at www.usb.org/developers/onthego. In USB OTG, some devices can act as hosts and non-host devices, and are termed dual-mode devices.

In USB OTG, the power supply V_{BUS} need not be provided if the bus is not being used. A dual-mode device that wants to adopt host status can signal on the bus that host status is required using V_{BUS} pulsing, which is effective whether or not V_{BUS} is supplied with a voltage supply. A dual-mode host is not able to provide a voltage supply on V_{BUS}, but by signalling can request a host device not having host status to provide a Voltage supply for use by the dual-mode device. The voltage supply is specified by the USB standard to be between 4.4 Volts and 5.25 Volts. PCs and laptops tend to provide V_{BUS} of at least 4.75 Volts. Mobile telephones and PDAs (personal digital assistants) will be non-host devices, not host or dual-mode devices, although it is anticipated that a subsequent generation of such devices could be dual-mode devices.

According to a first aspect of the invention, there is provided a device operable as USB host and having a USB port forming part of a USB bus, in which the device

includes means for detecting the presence of another USB host and for relinquishing host status in response thereto.

Such a device can operate as a host device on the USB bus, yet relinquishing host status when another host is detected allows the device to be used with USB host devices which are not specially adapted for use in multi-host USB systems. The device may be one specially designed for operation with devices operating according to the USB on-the-go standard.

Preferably the device includes a power supply for providing a supply voltage on a V_{BUS} line of the USB bus, allowing it to supply power to a USB non-host device connected to the bus. Preferably the supply voltage is less than 4.4 Volts, which is the minimum required by the USB standard, which allows operation with USB non-host devices which do not rely on a USB power supply according to the standard. If the detecting means includes means for detecting a change in voltage on a or the V_{BUS} line of the USB bus, the presence of the other USB host can be detected in a simple manner, for example using a comparator.

When another USB host is detected, the device advantageously causes at least some lines of the USB bus to be presented with a high impedance. The impedance is likely to be at least one megaohm. This prevents the device interfering to an unacceptable degree with subsequent communications on the bus, with which the device is not an active participant. Send a USB reset command via the USB bus in response to detecting the presence of another USB host is advantageous since it can cause a non-host device (or a dual-mode device acting as a non-host) on the bus to be reset ready for communication with the newly connected host device..

The device preferably includes means for detecting the loss of the other host, and for reassuming host status in response thereto. The loss detecting means advantageously includes means for detecting a reduction in voltage on a or the V_{BUS} line of the USB bus, thereby detecting loss of the other host.

Preferably the device includes first and second USB ports, which are preferably connected directly to the USB bus and hereby also directly to each other. The device can therefore have pass-through USB capabilities. This allows the connection of a non-host device (or a dual-mode device operating as a non-host device) to one port and the connection of a host device to the other port. When a host is detected, the device can act as a pass-through device but act as a host device otherwise. The device may include a digital video broadcast receiver, such as a DVB-T receiver.

According to a second aspect of the invention, there is provided a system including a device according to the first aspect of the invention, and a host device connected to the USB port. The system preferably includes a non-host device connected to a or the second USB port of the device.

According to a third aspect of the invention, there is provided a device operable as a host device and having a port forming part of a bus, in which the device includes means for detecting the presence of another host connected to the bus and for relinquishing host status in response thereto. The bus is preferably a serial bus. Preferable features include features corresponding to those described above in relation to the first aspect of the invention.

According to a fourth aspect of the invention, there is provided a system including a device according to the third aspect of the invention, and a host device connected to the port, which is preferably a serial port. The system could include a non-host device connected to a or the second port of the device.

According to a fifth aspect of the invention, there is provided a method of operating a device operable as a USB host, the method comprising detecting a change in voltage on a V_{BUS} line forming part of a USB bus; and relinquishing host status in response thereto.

According to a sixth aspect of the invention, there is provided a device operable as a USB host device, the device including first and second USB ports connected

directly to each other and to a USB host module. The ports are likely in a practical implementation to be connected together by a USB bus, also connected to the USB host module. This is a particularly convenient arrangement which can allow connection to a USB non-host device (or a dual-mode device operating as a non-host device), whilst also allowing a USB host device to be connected to the non-host device via the device of the invention. Thus, the device of the invention does not need to be disconnected from the non-host device when it is required to connect a host device to the non-host device. This invention is seen to have particular application for use with portable non-host devices, particularly those operating according to the USB on-the-go standard.

According to a seventh aspect of the invention, there is provided a radio transceiver comprising first and second USB ports each connected to a USB bus, and one of a) a USB non-host module and b) a USB dual-mode module connected to the USB bus. This can allow the attachment to one port of an accessory device having USB communication capabilities to communicate with the module and/or with a host device connected to the other port. Preferably, the module is able to communicate as a non-host with a host connected to either port. One port might be connected to a device according to the first or the third aspects of the invention.

In the above, each port may include a male or a female connector. Each port is for allowing connection to an external device.

The invention allows for a new class of device which is operable as a host device but which relinquishes host status, and preferably goes into a standby mode, on detecting the presence of another host. Preferably, the detection involves detecting a change in voltage on a supply line of a bus to which the port is connected. Providing the device with means to provide a voltage on the supply line which is less than the minimum allowed voltage on that line is advantageous since it can allow the detection of another host quite simply. On detecting the presence of another host, lines connected to the port are preferably forced tri-state, or high impedance, so the device does not interfere with the control of the bus by the other host.

Preferably, the device sends a reset command before or at the same time as relinquishing host status. By monitoring the supply voltage line of the bus, the device can detect when the other host is lost, by disconnection or disablement for instance, and take steps to reassume host status. Detection can result from detecting a voltage drop, preferably below a threshold, which is preferably set lower than the minimum allowed voltage. In a preferred embodiment, the threshold is set at less the one half the minimum allowed voltage.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a system including three devices connected together by a USB bus, according to various aspects of the invention;

Figure 2 is a circuit diagram of one embodiment of a comparator circuit used in the Figure 1 system; and

Figures 3, 4 and 5 are schematic diagrams of alternative embodiments of the Figure 1 system.

Referring to Figure 1, three devices 10-12 are shown connected to a USB bus 13. A PC 10 includes a USB host module 14, which is connected to D+, D- and ground lines thereafter termed 'the other lines' 15 of the USB bus 13, and a 5 Volt power supply 16, which is connected to a supply voltage line V_{BUS} of the USB bus. The PC 10 is a conventional device, operating according to the USB standard without the OTG supplement. A mobile telephone (or alternatively a PDA) is also connected to the USB bus 13. In particular, a USB non-host module 17 is connected to the other lines 15, so that the mobile telephone 11 can communicate with another device connected to the USB bus 13. The mobile telephone 11 also includes a regulator 18, which is connected to V_{BUS}. The regulator 18 is arranged to convert the voltage supply provided on V_{BUS} to a 3.3 Volt supply, which is suitable for use by the mobile telephone 11. Any convenient form may be used for the regulator 18.

An accessory device 12 is also connected to the USB bus 13. The accessory device 12 is not a non-host device nor a dual-mode device; rather it is a host device which does not operate strictly according to the USB or the USB OTG standards. The accessory device 12 is intended for connection to mobile telephones, PDAs and the like which have USB ports but which do not require a voltage supply within the standard range of 4.4 to 5.25 Volts. In this example, the accessory device 12 is dedicated for use with such mobile telephones, PDAs etc, to the extent that it would not function properly if used with devices conforming to the full USB standard. The accessory device 12 may be for example a DVB-T (digital video broadcasting - terrestrial)receiver. Alternatively, it could be a GPS (global positioning system) module, an FM radio module, a camera module, a wireless LAN module, a Bluetooth (TM) module, or a receiver for any of the ISDB-T, ATSC and DAB systems, for example. It is a USB host device since it is intended for connection to mobile telephones and PDAs, which do not have host capabilities. The accessory device 12 includes a USB host module 19, connected to the other lines 15 of the USB bus 13, a 4 Volt power supply 20, which is connected to V_{BUS}, and a comparator 21. The comparator 21 includes a first input connected to V_{BUS}, a second input connected to a reference voltage V_{REF}, and an output IRQ, which is connected to an interrupt input of the USB host module 19. The power supply 20 may alternatively provide any suitable voltage, the range 3.6 to 4.2 volts being suitable for this example.

The USB host module 19 has a control output CTRL connected to a control input of the power supply 20, by which the USB host module can control whether the power supply provides a 4 Volt supply or presents a high impedance to V_{BUS}.

Operation may begin with the mobile telephone 11 connected to the accessory device 12 by the USB bus 13, with the PC 10 being unconnected. In this state, the accessory device 12 provides a voltage supply on V_{BUS}, which is used by the mobile telephone 11 after conversion to 3.3 Volts (for example) by the regulator 18. Here, the accessory device 12 acts as a host to the non-host mobile telephone 11, and communication between the two device occurs using the other lines 15 of the USB

bus 13. In this state, IRQ is inactive, so the USB host module 19 is not interrupted, and CTRL is active, causing the voltage supply 20 to provide 4 Volts to V_{BUS}.

When subsequently the PC 10 is connected to the USB bus 13, the following occurs. As the PC 10 is connected, the voltage on V_{BUS} rises as a result of the voltage supply 16. When the voltage on V_{BUS} exceeds a threshold of 4.2 Volts, this is detected by the comparator 21, which sends IRQ active, to activate an interrupt. The USB host module 19 on detecting that IRQ has gone active takes a number of actions. Firstly, the USB host module 19 sends a reset command on the D^+ and D^- lines 15, which causes resetting of the USB non-host module 17 of the mobile telephone 11. Secondly, the USB host module 19 causes the accessory device 12 to relinquish host status by going tri-state, that is by presenting a high impedance to each of the D^+ and D^- lines 15. The impedance is typically several megaohms, but is at least one megaohm. Lastly, the USB host module 19 sends CTRL inactive, in response to which the voltage supply 20 is controlled to cease providing a supply voltage for V_{BUS} and to tri-state, i.e. present a high impedance to V_{BUS}. As a result, the PC 10 is able to assume host status with the mobile telephone 11 whilst the accessory device 12 waits in a standby mode.

When the PC 10 is subsequently disconnected, because it is physically removed from the bus 10 or its USB host module 14 is switched off for example, the following occurs. As the voltage on V_{BUS} falls (neither voltage supply 16, 20 is supplying V_{BUS}), the comparator 21 in the accessory device 12 detects this by detecting when the level falls below a threshold of 1.3 Volts (for example). On such a detection, the comparator 21 sends IRQ inactive, which wakes the USB host module 19, triggering it to reassume host status by sending CTRL active, causing the voltage supply 20 to supply V_{BUS} with 4 Volts, by removing the tri-state status of the D^+ and D^- lines 15. The accessory device 12 may then communicate with the mobile telephone 11 in the same way as occurred prior to the PC 10 being connected to the USB bus 13. It may be desirable to arrange for a delay between detecting the low voltage condition and waking the USB host module 19.

A preferred form for the comparator 21 will now be described with reference to Figure 2. Referring to Figure 2, the comparator 21 is shown implemented using an LMV331, produced by National Semiconductor, which has an open-drain output. The values of resistors R1 to R6 are selected such that the rising voltage threshold is 4.2 Volts and the falling voltage threshold is 1.3 Volts. To obtain this, R1 to R5 can be IMΩ resistors, with feedback resistor R6 being a 422kΩ resistor. All resistors have a 1% tolerance. It will be appreciated that the falling voltage threshold is not so important as the rising voltage threshold, which is set taking into account the minimum voltage required for the regulator 18 to operate and the minimum voltage which could be supplied to V_{BUS} by the USB host PC 10. Although the example above uses 4.2 Volts as the rising level threshold, the threshold could be anywhere in the range 3.8 to 4.4 Volts. The lower value depends on the voltage supplied by the voltage supply 20.

Referring now to Figure 3, a mechanical arrangement for connection of the components of the Figure 1 system is shown. The mobile telephone 11 includes a USB port 30, to which is connected a first and 31 of a first short USB cable 32. The other end 33 of the first USB cable 32 is plugged into a first USB port 34 forming part of the accessory device 12. Similarly, the PC 10 includes a USB port 35, in which is plugged a first end 36 of a second, longer USB cable 37. The other end 38 of the second cable 37 is plugged into a second USB port 39 of the accessory device 12. In the accessory device 12, connections of the first USB port 34 are connected by respective wires directly to corresponding connections of the second USB port 39, allowing USB communication between the PC 10 and the mobile telephone 11 without involving the accessory device. In this example, the VBUS line is shown, and the other lines are grouped together as 40. The comparator 21, the voltage supply 20 and the USB host module 19 are connected to respective ones of VBUS and the other lines, as described above in relation to Figure 1. Accordingly, when the PC 10 is not hosting the USB bus 13, the accessory device 12 can detect this and assume host status. In this example, the USB ports 30, 34, 38 and 35 each include a female connector, and the cable ends 31, 33, 38 and 36 each include a male connector. To prevent current being fed along V_{BUS} towards the

USB host 10, one of the cable end 38 and the second USB port 34 might include a suitably arranged diode (not shown) or other arrangement having a similar effect.

In an alternative arrangement (not shown), the first USB port 34 includes a male USB connector, which connects into the USB female connector 30 of the mobile telephone without the use of the first USB cable 32.

A cable-less arrangement is shown in Figure 4. Referring to Figure 4, a docking cradle 41 is provided at one end of the second USB cable, in place of the plug 38. The docking cradle includes a male USB plug 42, which mates with the second USB port 39 in the accessory device 12. The first USB port 34 of the accessory 12 includes a male connector, which plugs into a USB port 30 of the mobile telephone. No USB cables are required in this embodiment. A diode (not shown) or other device is connected to disallow flow of current along V_{BUS} towards the USB host.

A still further arrangement is shown in Figure 5. Referring to Figure 5, a mobile telephone 50 is provided with a connector to a battery pack 51, including a battery cell (not shown). The battery pack 51 could be termed an extension module or a side module. As well as the connector including the usual battery terminal connectors 52, it includes also a female USB connector 53, which connects with a male USB connector 54 of the battery pack 51 when fitted to the mobile telephone 50. A VBUS line and other lines 55 are connected to the USB connector 53, and to a USB non-host module 56 internal to the mobile telephone 50. These lines are also connected directly to a USB female connector 57, by which an external USB cable 58 having a male connector 59 can be connected to the USB non-host module 56, allowing connection of a USB host, such as a PC (not shown). Although not shown, the battery pack 51 includes the same circuitry as the accessory devices 12 described in the above embodiments. A diode (not shown) or other device is included in the USB female connector 57 or the USB male connector 59, to prevent current flowing towards the USB host. The battery pack 51 may include a DVB-T (digital video broadcasting - terrestrial) receiver (not shown) or the like, which communicates with the mobile telephone 51 using the USB bus 55, VBUS.

Claims

1. A device operable as USB host and having a USB port forming part of a USB bus, in which the device includes means for detecting the presence of another USB host and for relinquishing host status in response thereto.

2. A device as claimed in claim 1, including a power supply for providing a supply voltage on a V_{BUS} line of the USB bus.

3. A device as claimed in claim 2, in which the supply voltage is less than 4.4 Volts.

4. A device as claimed in any preceding claim, in which the detecting means includes means for detecting a change in voltage on a or the V_{BUS} line of the USB bus , thereby detecting the presence of the other USB host.

5. A device as claimed in claim 4, in which the change is an increase.

6. A device as claimed in claim 4 or claim 5, in which the detecting means includes a comparator.

7. A device as claimed in any preceding claim, in which the device is arranged for causing at least some lines of the USB bus to be presented with a high impedance, preferably at least one megaohm, on detecting the presence of another USB host.

8. A device as claimed in any preceding claim, including means to send a USB reset command via the USB bus in response to detecting the presence of another USB host.

9. A device as claimed in any preceding claim, including means for detecting the loss of the other host, and for reassuming host status in response thereto.

10. A device as claimed in claim 9, in which the loss detecting means includes means for detecting a reduction in voltage on a or the V_{BUS} line of the USB bus, thereby detecting loss of the other host.

11. A device as claimed in any preceding claim in which the device includes first and second USB ports.

12. A system including a device as claimed in any preceding claim and a host device connected to the USB port.

13. A system as claimed in claim 12, including a non-host device connected to a or the second USB port of the device.

14. A device as claimed in any of claims 1 to 10, in which the device is a battery pack.

15. A device as claimed in any of claims 1 to 10 or 14, in which the device includes a digital video broadcast receiver.

16. A device operable as a host device and having a port forming part of a bus, in which the device includes means for detecting the presence of another host connected to the bus and for relinquishing host status in response thereto.

17. A device as claimed in claim 16, including a power supply for providing a supply voltage on a voltage supply line of the bus.

18. A device as claimed in claim 16 or claim 17, in which the detecting means includes means for detecting a change in voltage on a or the voltage supply line of the bus, thereby detecting the presence of the other host.

19. A device as claimed in claim 17, in which the change is an increase.

20. A device as claimed in claim 18 or claim 19, in which the detecting means includes a comparator.

21. A device as claimed in any of claims 16 to 20, in which the device is arranged for causing at least some lines of the bus to be presented with a high impedance, preferably at least one megaohm, on detecting the presence of another host.

22. A device as claimed in any of claims 16 to 21 including means to send a reset command via the bus in response to detecting the presence of another host.

23. A device as claimed in any of claims 16 to 22, including means for detecting the loss of the other host, and for reassuming host status in response thereto.

24. A device as claimed in claim 23, in which the loss detecting means includes means for detecting a reduction in voltage on a or the voltage supply line of the bus, thereby detecting loss of the other host.

25. A device as claimed in any of claims 16 to 22, in which the device includes first and second ports.

26. A system including a device as claimed in any of claims 16 to 25, and a host device connected to the port.

27. A system as claimed in claim 26, including a non-host device connected to a or the second port of the device.

28. A device as claimed in any of claims 16 to 24, in which the device is a battery pack.

29. A device as claimed in any of claims 16 to 24 or 28, in which the device includes a digital video broadcast receiver.

30. A method of operating a device operable as a USB host, the method comprising:

detecting a change in voltage on a V_{BUS} line forming part of a USB bus; and

relinquishing host status in response thereto.

31. A method of operating a device operable as a USB host as claimed in claim 26, in which the change is an increase.

32. A method of operating a device operable as a USB host as claimed in claim 26 or 27, further comprising in response to a detection, causing at least some lines of the USB bus to be presented with a high impedance, preferably at least one megaohm.

33. A method of operating a device operable as a USB host as claimed in any of claims 26 to 28, further comprising in response to a detection, sending a USB reset command via the USB bus.

34. A method of operating a device operable as a USB host as claimed in any of claims 26 to 29 further comprising, in response to a detection, ceasing to supply a voltage to V_{BUS}.

35. A method of operating a device operable as a host, the method comprising:

detecting a change in voltage on a voltage supply line forming part of a bus; and

relinquishing host status in response thereto.

36. A method of operating a device operable as a host as claimed in claim 30, in which the change is an increase.

37. A method of operating a device operable as a host as claimed in claim 31 or 32, further comprising, in response to a detection, causing at least some lines of the bus to be presented with a high impedance preferably at least one megaohm.

38. A method of operating a device operable as a host as claimed in claims 31 to 33, further comprising in response to a detection, sending a reset command via the bus.

39. A method of operating a device operable as a host as claimed in any of claims 31 to 34 further comprising, in response to a detection, ceasing to supply a voltage to the supply line.

40. A device operable as a USB host device, the device including first and second USB ports connected directly to each other and to a USB host module.

41. A mobile telecommunications device comprising first and second USB ports each connected to a USB bus, and one of a) a USB non-host module and b) a USB dual-mode module connected to the USB bus.

42. An accessory device substantially as described with reference to and/or as shown in any of Figures 1, 3 and 4 of the accompanying drawings.

43. A mobile communications device substantially as described with reference to and/or as shown in Figure 5 of the accompanying drawings.

Abstract

Devices

An accessory device 12, such as a DVB-T receiver is operable as a USB host to a mobile telephone 11 to which it is connected via a USB bus 13. When acting as a host, the accessory device 12 provides a 4V supply voltage on V_{BUS} to the mobile telephone, which includes a regulator 18 regulating the voltage to 3.3 Volts. When a host device (PC) 10 is also connected to the USB bus 13, the voltage on V_{BUS} rises, and this is detected by a comparator 21. In response, the accessory device 12 sends a USB reset command sends its USB lines tri-state, and ceases to supply V_{BUS}, thereby relinquishing host status. Loss of the PC 10 is detected by detecting a low voltage on V_{BUS}, following which the accessory device reassumes host status.

Figure 1

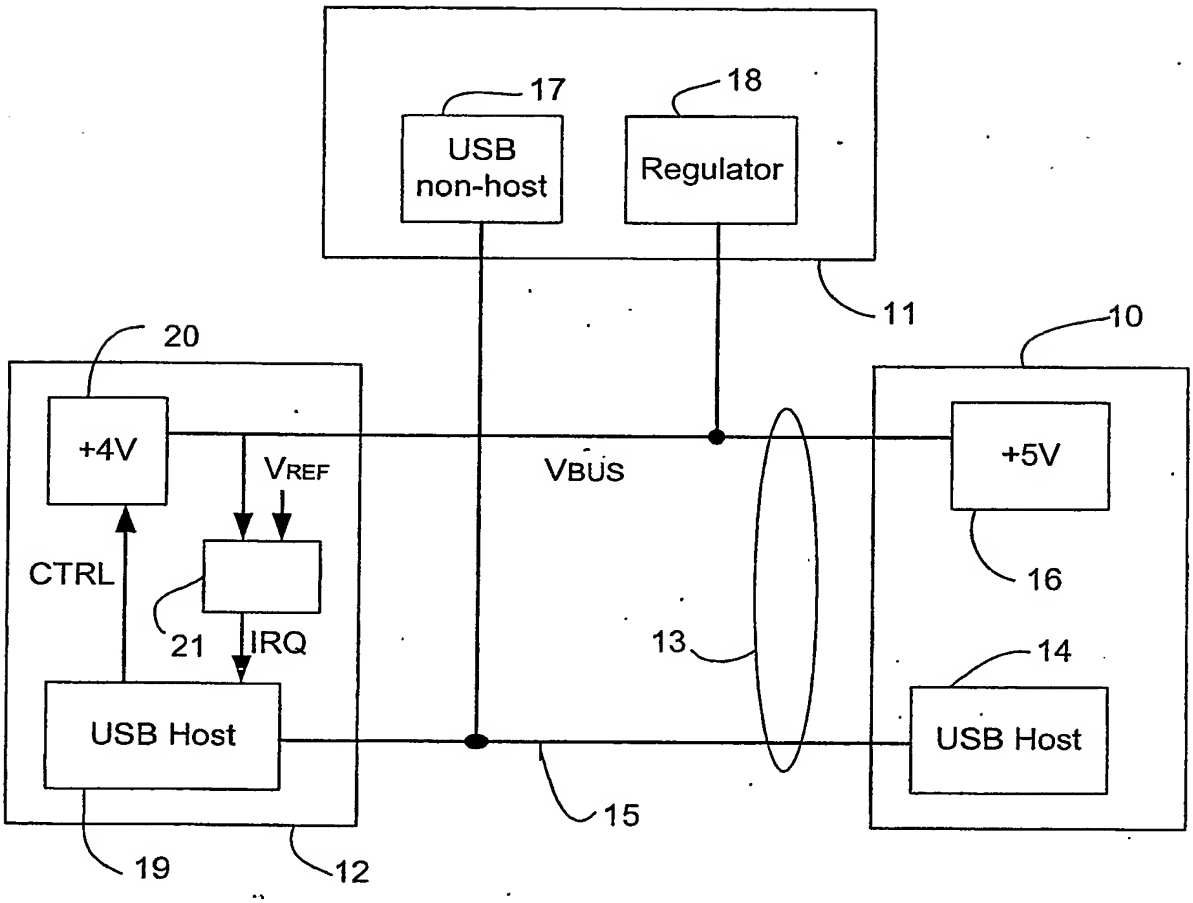
17
18
USB non-host
Regulator
11
10
20
+4V
VREF
VBUS
+5V
CTRL
16
21
IRQ
13
14
USB Host
USB Host
15
19
12

Figure 1

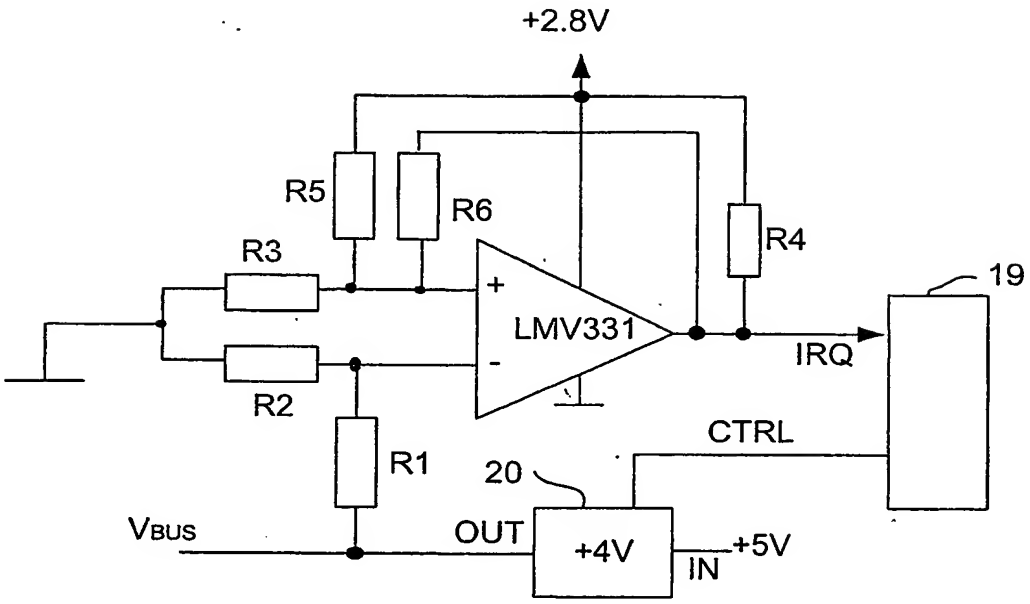

Figure 2

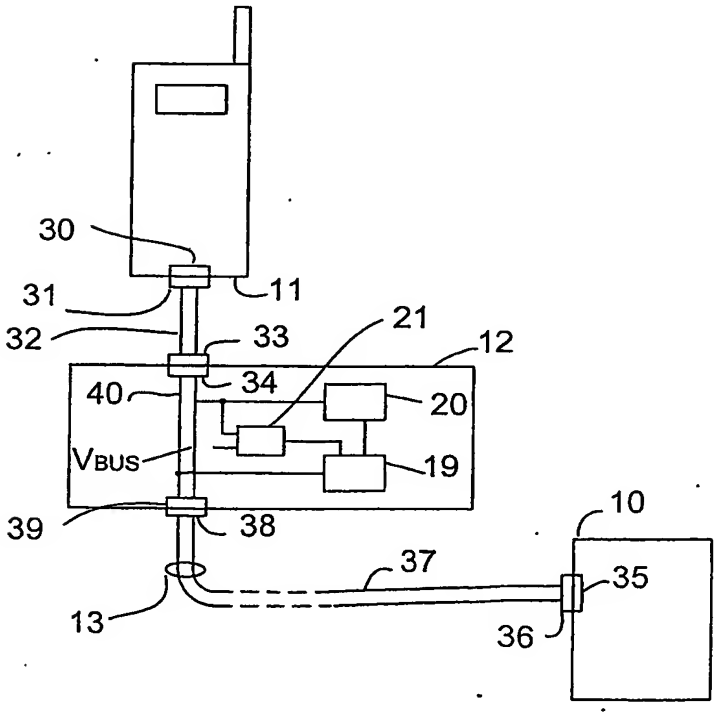

Figure 3

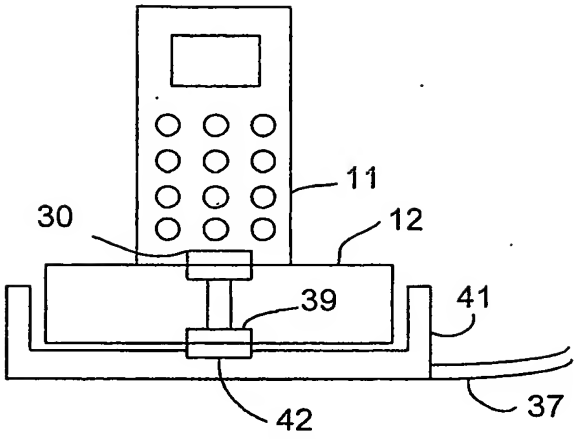

Figure 4

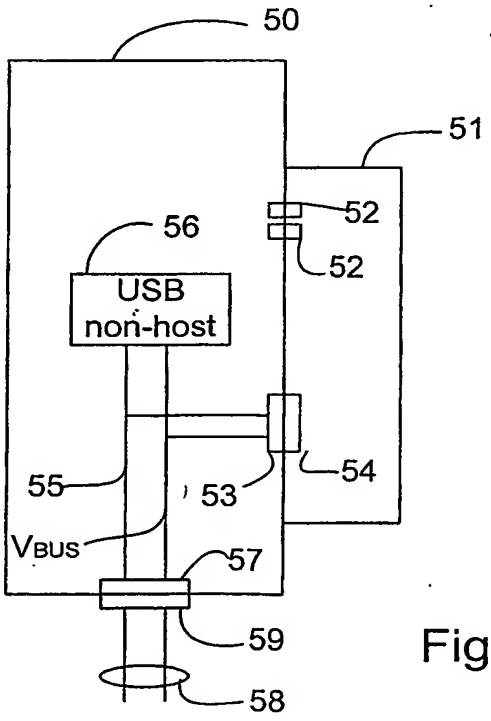

Figure 5

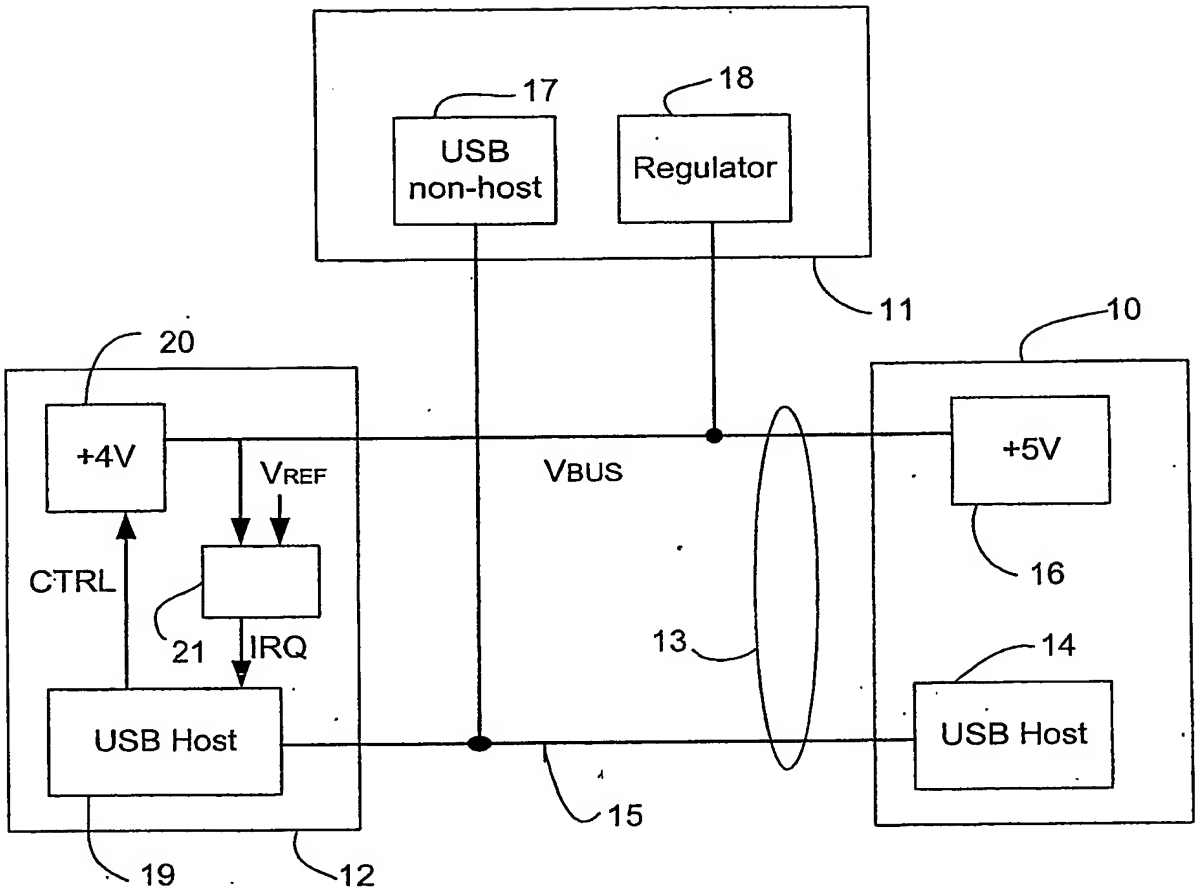
17
18
USB non-host
Regulator
11
10
20
+4V
VREF
VBUS
+5V
16
CTRL
21
IRQ
13
14
USB Host
USB Host
15
19
12

Figure 1

PCT Application
EP0350672